HERMANN VON HELMHOLTZ—THE INVENTOR OF THE OPHTHALMOSCOPE.*

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CHICAGO.

Vormals im Leben ehrten wir dich, wie einen der Goetter,
Nun du todt bist, so herrscht über die Geister dein Geist.

Quite apart from the interest that is naturally excited by the life-story of the great scientist who invented the instrument that revolutionized the science and art of ophthalmology, there are, at least, two reasons why this gathering should be especially interested in the life of Hermann Ludwig Ferdinand Von Helmholtz. In the first place it was as a student and practitioner of medicine that he entered upon those studies that carried his name and spread his fame throughout the world of science. Then, in the second place, there coursed in his veins the bluest of American blood. His mother was the daughter of a Hanoverian artillery officer named Penne, a direct descendant of William Penn. It is more than possible that the calm, thoughtful spirit which distinguished all the actions of this truly great man was largely due to the Quaker element in his character. He was born at Potsdam, near Berlin, on August 31, 1821—the son of Ferdinand Helmholtz, a teacher in the gymnasium, and a man of unusual intelligence and culture. The subject of this sketch had, on the whole, a quiet uneventful life. He was not given to talking much about himself even to his most intimate friends, although he occasionally broke through his natural reserve in this respect. In 1891, when he replied to a toast in honor of

* At the Meeting at Atlantic City, Drs. Harry Friedenwald and Casey Wood were appointed a committee to arrange exercises and an historic exhibit for the St. Paul Meeting, to commemorate the 50th anniversary of the invention of the ophthalmoscope.

his seventieth birthday, he opened his heart to his hearers, and we are indebted to this festive occasion for much that we know of the private life and opinions of the speaker. Although by no means robust as a boy, his mind always showed great activity. He tells us that it was while playing with a set of wooden blocks that his attention was first drawn to mathematical problems. He had the good fortune to possess a father who encouraged him in the study of general literature, and although he acquired languages with great difficulty, he was very fond of poetry, and at an early age read Homer, Virgil and even Arabic tales and verse. He also had the advantage of listening to the discussions, philosophical and other, that took place in his father's house, and made an early acquaintance with the metaphysics of Kant and Fichte. As he grew older he threw off the physical disabilities that affected his early youth and began to take long walks through the country, first in the beautiful environs of Potsdam and later through Europe, that formed, with the delightful and profitable companionship of his father and other friends, one of the most fruitful experiences of his whole life. Du Bois Reymond asserts that these excursions, as well as his later mountaineering experiences in the Alps, had for him something more than a hygienic value. We know that the solution of many a problem came to him while engaged in these holiday recreations. For example, it was while watching the troubled sea at Cap d'Antibes that he measured the velocity of the wind with an anemometer, counted the number of waves on a given surface of sea and thus obtained the necessary data for his conclusions on the relation of wind velocity to wave lengths.

Helmholtz was soon attracted by the study of physics as opposed to mere abstract investigation of algebra, geometry and trigonometry, and although he regarded mathematics as a *sine quâ non* in physical research, he was essentially a student of physical phenomena. If there is one thing that characterizes his life-work it is a passionate desire to know things as they really are and to study them especially from their physical side. This zeal became more pronounced the older he grew, and we know that as an experimenter he had no superior and few equals. While his class in the gymnasium was reading Greek and Latin authors, generally regarded as a severe task by the young physicist, he was surreptitiously working out optical problems and illustrating the passage of light rays through the telescope. His father was a man of small means and could not afford to purchase expensive apparatus for his son; hence the latter was obliged to utilize in his primitive investigations spectacle glasses and a small lens used for examining botanical specimens.

In 1838 he left the gymnasium to attend the University at Berlin with the following prophetic testimonial from the rector: "His exceptionally calm and reserved disposition is combined with great intellectual enthusiasm. In it we recognize an excellent combination of clear and prudent understanding and deep good nature. His manners bear witness to a carefully preserved, exceptionally pure, and genuine childlike innocence. These peculiarities, along with the richness and power of his mental development, give an agreeable and captivating impression, and justify the hope that such a ground-soil of intellectual life will only bring forth the best of fruits."

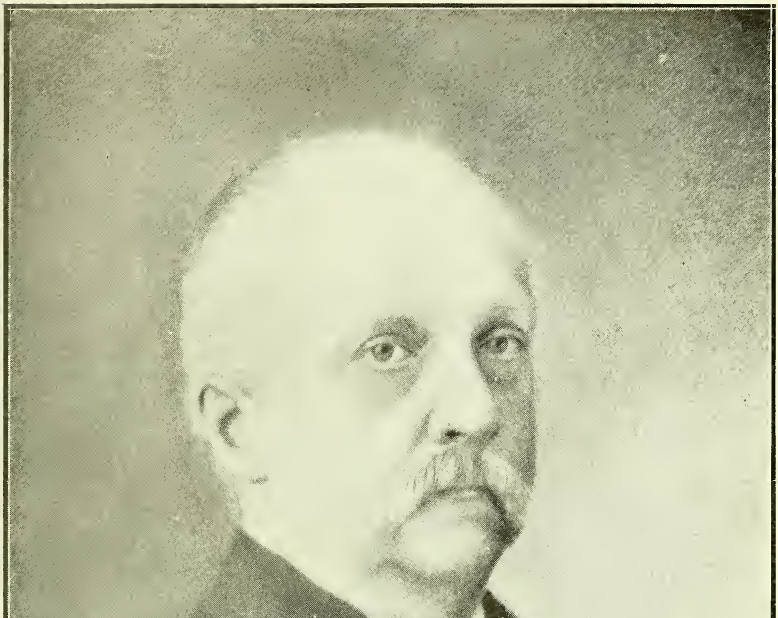
It is difficult to realize from what we know of his maturer years, that Helmholtz had no extensive training in mathematics during his youth. It appears, however, that he recognized the necessity of a thorough knowledge of this branch as an adjunct to his study of physics, and he applied himself to it with the quiet persistence that also marked his successful acquirement of foreign languages. Those of us who remember the speech he made at the dinner in his honor at Chicago in 1893 will scarcely believe that he was not a ready linguist.

Helmholtz was one of four children, and the difficulties which Ferdinand Helmholtz encountered in supporting his family made it necessary that Hermann should earn his own livelihood at an early age. He was advised to study medicine and, with the assistance of a relative, Surgeon-General Mursinna, in 1838, entered as a bursar the Royal Medical-Chirurgical Friedrich-Wilhelm Institute in Berlin. Here a free medical education was given the student on condition that he afterwards become a surgeon in the Prussian army. He attended the usual courses in the Medical Department of Berlin University, was attached for a time to the Charité Hospital, finally obtained his diploma and became an army surgeon.

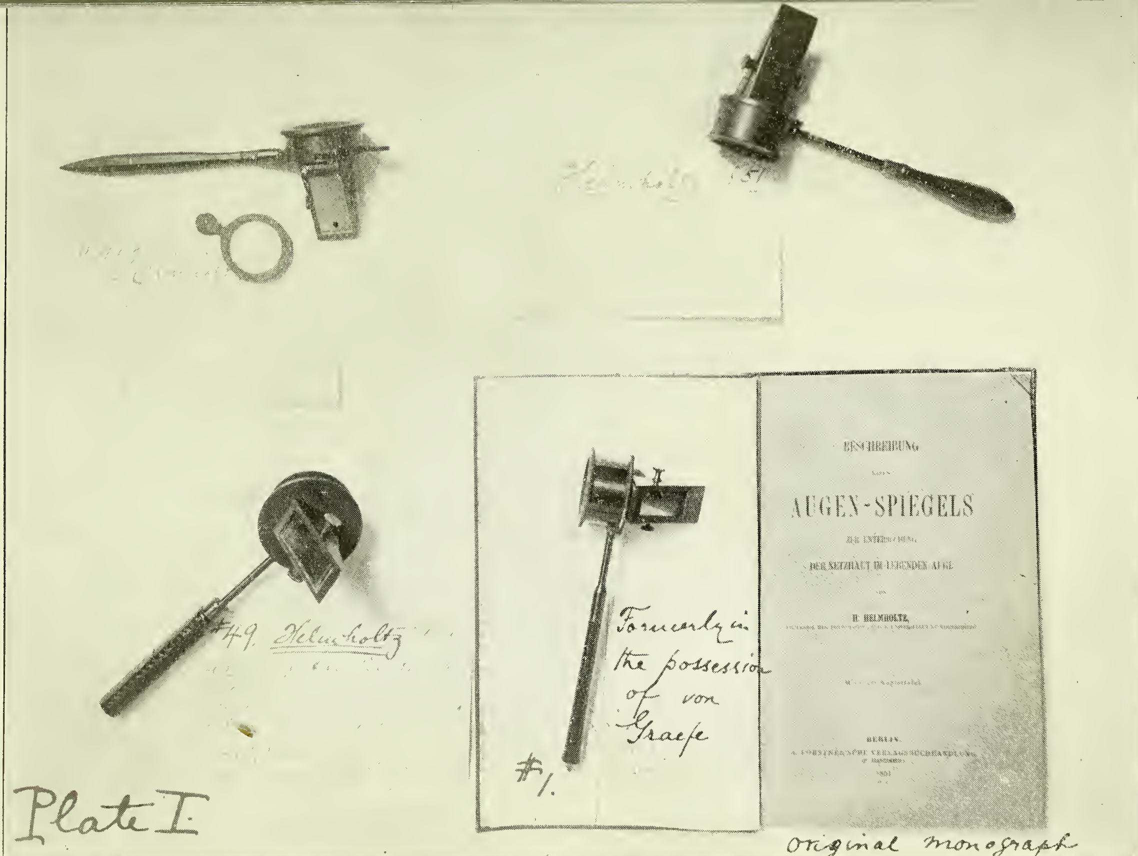
In a lecture delivered in 1877 on "Thought in Medicine," a lecture which I respectfully commend to the attention of all who have not carefully read it, he speaks of this period of his life. "My own original inclination," said he, "was towards physics; external circumstances obliged me to commence the study of medicine. It had, however, been the custom of a former time to combine the study of medicine with that of the natural sciences, and whatever in this was compulsory I must consider fortunate; not merely that I entered medicine at a time in which any one who was even moderately at home in physical considerations found a virgin field for cultivation, but I consider the study of medicine to have been that training which preached more impressively and more convincingly than any other could have done, the everlasting principles of all scientific work; principles which are so simple and yet are ever forgotten again; so clear and yet always so hidden by a deceptive veil."

It was during this time that he became the associate—the fortunate associate—of a number of other students in Berlin whose names are now and ever will be as household words to the medical man—Johannes Müller, Du Bois Reymond (an old school friend) Brücke, Gustav Magnus, Kirchoff, Virchow and many others of that brilliant group who, with himself, became the founders of the Berlin Physical Society. The main function of this association was, as you know, to consider physiological and other problems from the physical rather than from the metaphysical side.

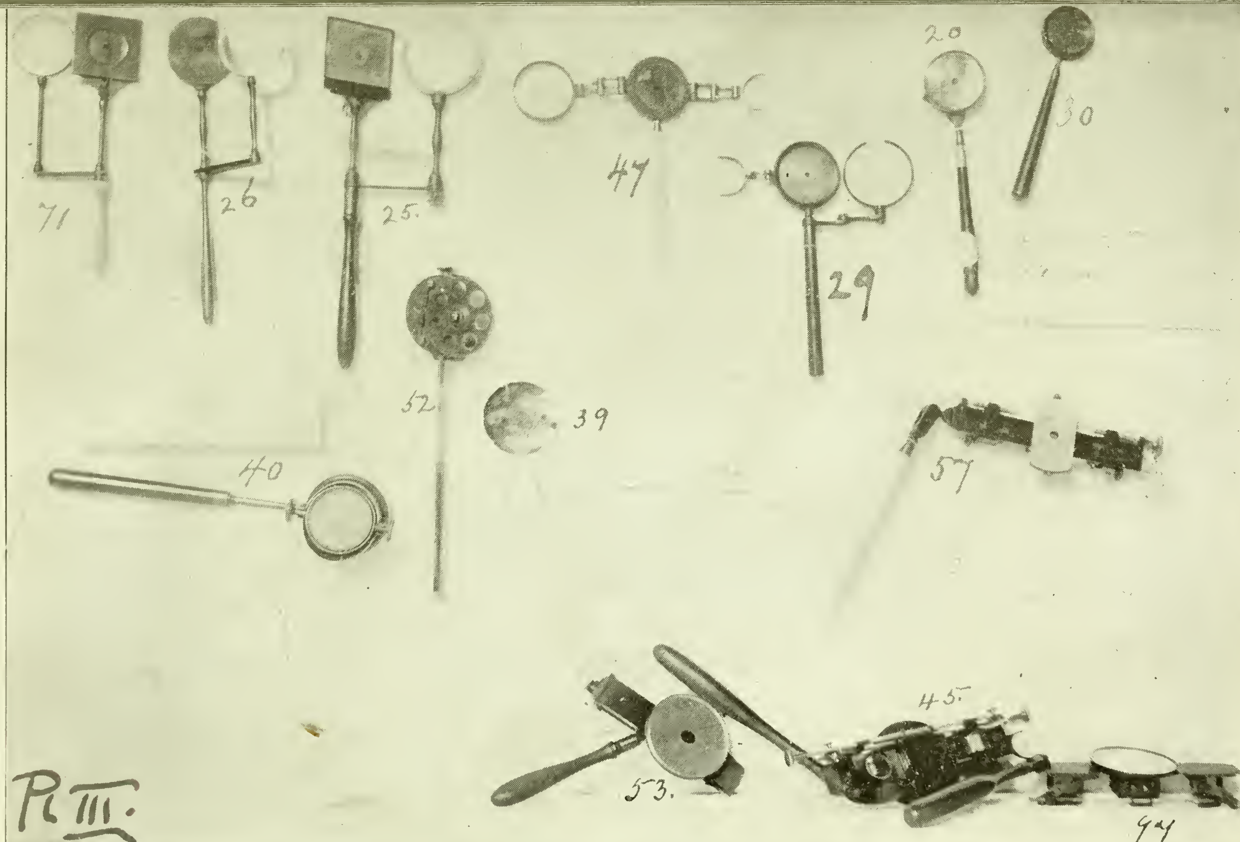
While engaged in his usual medical duties, Helmholtz had, as he tells us in "Thought in Medicine," an attack of typhoid fever, for which he was treated gratuitously in the Charité. As his allowance for board was in the meantime continued, he found himself at the end of his convalescence in the possession of a small sum of money, which he invested in a compound microscope. Do not imagine for a moment that this was one of those expensive and effective instruments with which every medical college is nowadays liberally supplied. In Helmholtz's youth microscopes were rare, and microscopical research by the student still rarer. Yet with this primitive instrument he demonstrated in the nervous ganglia of leeches that the nerve fiber or its axis cylinder always originates from the polar process of the nerve cell, and



Prof. H. von Helmholtz.


#49. Helmholtz
Formerly in the possession of von Graefe
#1.
BESCHREIBUNG
AUGEN-SPIEGELS
DER NETZHAUT IM LEBENDEN AUGE
H. HELMHOLTZ,
BERLIN.
Original monograph
Plate I.

Pl. II.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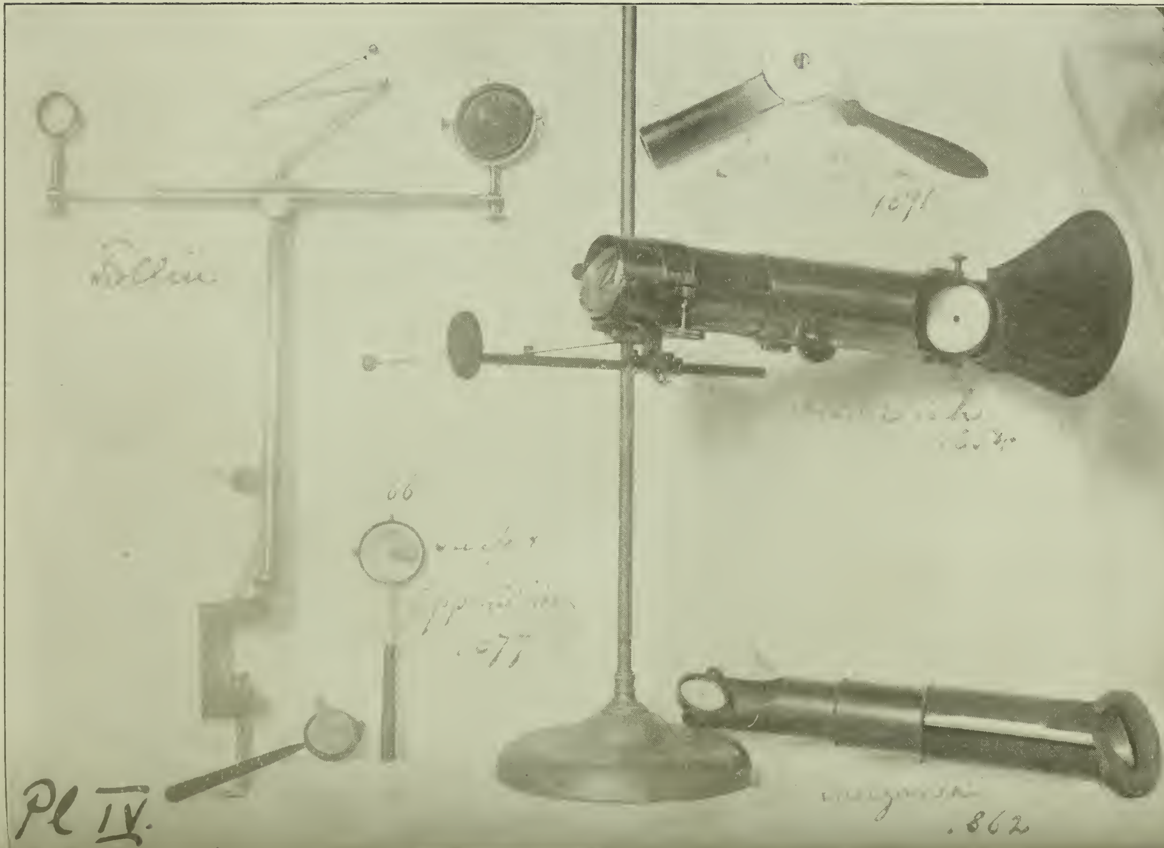
Pl. III.


Pl IV.
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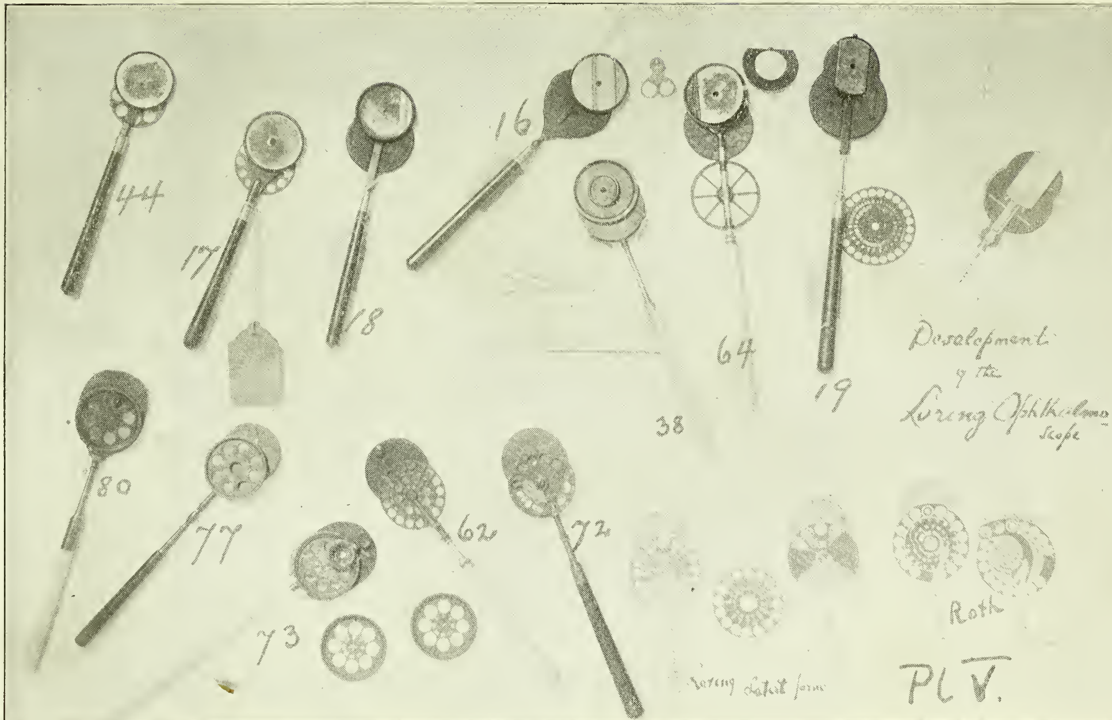
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Development
of the
Loring Ophthalmo-
scope
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Roth
Loring latest form
Pl V.

this investigation formed the basis of that inaugural thesis (De Fabrica systematis nervosi Evertebratorum) which at the age of 21 he presented on graduation. Sometimes we are led to believe, and our splendidly equipped laboratories in a certain sense reflect this belief, that it is a particular kind of tool that plays the important part in the work of original research, without a reckoning of the workman, just as occasionally we lose sight of the "man behind the gun" in estimating the probable value of the firearm.

It is not the purpose of this paper to follow, from these beginnings, Helmholtz's triumphant progress through the world of physical science. Even a short account of the additions which he made to our knowledge of chemistry, physiology, mechanics, hydrodynamics, optics, acoustics, electricity, color and mathematical physics generally, not to mention their practical application in the invention of instruments of precision, would more than occupy the time at my disposal. McKendrick says of him that from 1842, when his thesis was published at 21 years of age, until 1894, when he died, papers flowed from his pen in almost uninterrupted succession. With the exception of the year 1849 he always published at least one important contribution, so that no fewer than 217 distinct papers and books represent his labors. He lived in Berlin from 1842 to 1847, when he became, at the age of 29, professor of physiology at Königsberg. There he remained until his 35th year (in 1856) when he was promoted to the chair of physiology in Bonn. In 1859 he was made professor of physiology in Heidelberg. When 50 years old he was called to occupy the chair of physics in Berlin, and there he remained until his death. His early years in Berlin were occupied as assistant physician at the Charité and as assistant surgeon in the Red Hussars regiment at Potsdam. He never had a private medical practice; indeed, we know that every moment he could spare from his public medical duties was devoted to physical science. Eventually Alexander von Humboldt, recognizing his capacity, asked that he be relieved from all military duty and obtained for him several minor positions where he could devote most of his time to the study of anatomy and physiology.

As a student, some fifteen years ago, in the Physiological Institute of Berlin University, it was my good fortune to have been thrown in contact with many of the teachers that have made that institution famous—with Helmholtz, Du Bois Reymond, König, Fritsch, Gad and others of the same school. No one could fail to be impressed by the spirit of earnestness, simplicity and devotion to science for its own sake that characterized the labors of these brilliant investigators. I can not refrain from mentioning a circumstance illustrative of this idea, that is familiar to most of you. At intervals the students and teachers of the Institute were invited for a social gathering to some convenient place where all topics imaginable—but especially scientific subjects—were discussed. One in particular I remember at which Helmholtz and Du Bois Reymond were present. It was called, if I recollect aright, in the invitation posted at the Institute, *eine Bier-microscopische Versammlung,* a term fairly descriptive of the entertainment, because we wore our everyday clothes, drank beer, ate sandwiches, examined microscopical slides, listened to animated scientific discussion and enjoyed what then, and what still seems to me to be the very best society in Germany. Probably a corresponding entertainment would be represented in some other countries by an orchestra behind a row of palms, floral decorations, ten courses of indigestible imitations of French cooking and all the "guests" in their "dress" suits and on their finest behavior. Whenever I attend a medical "banquet" I can not help breathing a sigh for the simple (primitive, if you will) social joys of the German University.

Something, by the way, ought to be here said about the important work which Helmholtz did in perfecting the microscope—in supplementing the labors of Abbé of Jena in this direction. Among many other things he showed us how to find and measure the angle of aperture, and he proved that because of the light-dispersion at the margins of minute objects none of these can be seen that are of a smaller diameter than 1/5000 of a millimeter.

In some form or other and at some time or other the great problems relating to the forces that play in us and about us occupy one's attention, and Helmholtz endeavored to solve some of these great questions (so far as physical research can ever solve them) in his famous essay, "Ueber die Erhaltung der Kraft." Although the principle of the conservation of energy is now so universally accepted as to be considered almost axiomatic, and though it was dimly realized by Newton, Descartes and others, this paper of Helmholtz, read before the Physical Society, aroused much criticism, and it was actually refused publication in the well-known *Annalen* of Poggendorff on account of its doubtful value!

In 1849, when Helmholtz was 29 years of age, he married Frl. Olgo von Velten of Potsdam, who died at Heidelberg in 1859. He had by this marriage two children, a son, an engineer now living in Munich, and a daughter who became the wife of Professor Branco, the geologist.

In 1861 he entered upon a second marriage with Frl. Anna von Mohl, a lady belonging to a Wurtemberg family of high social position, who also bore him two children, a son and a daughter. Robert, the elder, died in 1889 after he had given evidence of having inherited many of the mental qualities of his distinguished father. It is said that Helmholtz never entirely recovered from this blow. The daughter married the son of Werner von Siemens, the well-known electrician.

Helmholtz was an accomplished musician and no mean vocalist. The pleasures of congenial society, with music, formed his principal recreation. It may be said, in passing, that the splendid grand piano upon which he loved to play was presented to him by the house of Steinway of New York in recognition of his services to music.

The answer which the devotee of pure science is likely to give to the objection raised by the so-called "practical" man that there is little value to be attached to merely theoretical investigations, might take the form of a reference to the invention of the ophthalmoscope which we may consider the most beneficial of all the works of Helmholtz. We have the testimony of the inventor himself that its origin was the outcome of a desire to exhibit a purely physiological phenomenon to his students in Königsberg. Its application in the diagnosis and treatment of disease was really an after-thought. As you are well aware, and as the labors of my colleague have enabled us so well to appreciate in the fine exhibits his industry has set before us, the first ophthalmoscope was a very crude instrument. For that matter, so also were the forerunners of the modern myograph, phakoscope and ophthalmometer, all invented at Königsberg by this versatile genius. As a further example of Helmholtz's universal study of men and things, Du Bois Reymond tells us that as a recreation he was in the habit of watching through a telescope the walking methods of the Königsberg citizens so that he might compare his observations of human locomotion with those of Weber.

In Bonn he wrote the well-known monograph on the ossicles and membrana tympani that forms so large a portion of modern physiological acoustics, just as his researches in physiological optics contributed so much to our knowledge of optical problems.

In 1864 he delivered the well-known Croonian lecture "On the Normal Motions of the Human Eye in Relation to Binocular Vision." His studies of the horopter and stereoscopic vision led to the invention of the telestereoscope which, as you well know, is an instrument where two images of distant objects are seen as if the foveæ were much more widely separated than normal.

Helmholtz was a sufferer from a form of hay fever that greatly interfered with his enjoyment of the *Ferienzeit.* As no one appeared to be able to relieve him, and as little was then known of the etiology of this strange disease, he, with his usual energy, attempted to discover its cause. A full account of these researches will be found in the 46th volume (1869), page 67, of Virchow's Archiv in an article by Professor C. Binz of Bonn, entitled "Pharmakologische Studien ueber Chinin." Having read the experiments of Binz with quinia sulphate on the organisms supposed to be responsible for the symptoms, Helmholtz used a nasal wash (1:800) of this remedy for four or five years and finally announced himself as cured. The following account of the attacks, their etiology as the sufferer himself worked it out, and the means he adopted for their cure, show what an admirable clinician he might have made. The English account is given in *Nature*, vol. x, page 26, and is entitled "An Experimental Observation on Hay Fever," being a letter to Professor Tyndall from Professor C. Binz in Bonn, and forwarded by the former for publication.

"I have suffered as well as I can remember since the year 1847 from the peculiar catarrh called by the English 'hay fever,' the specialty of which consists in its attacking its victims regularly in the hay season (myself between May 20 and the end of June), that it ceases in the cooler weather, but on the other hand quickly reaches a great intensity if the patients expose themselves to heat or sunshine. An extraordinary violent sneezing then sets in, and a strongly corrosive thin discharge with much epithelium is thrown off. This increases after a few hours to a painful inflammation of the mucous membrane and of the outside of the nose, and excites fever, with severe headache and great depression if the patient can not withdraw himself from the heat and the sunshine. In a cool room, however, these symptoms vanish as quickly as they come on, and there then only remains for a few days a lessened discharge and soreness, as if caused by the loss of epithelium. I remark, by the way, that in all my other years I had very little tendency to catarrh or catching cold, while the hay fever has never failed, during the twenty-one years of which I have spoken, and has never attacked me earlier or later in the year than the time named.

"The curious dependence of the disease on the season of the year suggested to me the thought that organisms might be the origin of the mischief. In examining the secretions I repeatedly found in the last five years certain vibrio-like bodies in it which at other times I could not observe in my nasal secretions. They are very small and can only be recognized with the immersion lens of a good Hartnack microscope.

"It is characteristic of the common isolated single joints that they contain four nuclei in a row, of which two pairs are more closely united. The length of the joints is 0.004 mm. Upon the warm objective-stage they move with moderate rapidity, partly in mere vibration, partly slowly backward and forward in the direction of their long axis; in lower temperatures they are inactive. Occasionally one finds them arranged in rows upon each other or in branching series. Observed some days in the moist chamber they vegetate and appear somewhat larger and more conspicuous than immediately after their excretion. It is to be noted that only that kind of secretion contains them which is expelled by violent sneezings; that which drops away slowly does not contain any. They stick tenaciously enough in the lower cavities and recesses of the nose. I made a neutral solution of sulphate of quinin (1 to 800) which produced moderate irritation of the nasal mucous membrane. I then lay flat on my back, keeping my head very low, and poured with a pipette about 4 c.c. into both nostrils. Then I turned my head about in order to let the fluid flow in all directions. The desired effect was obtained immediately and remained for some hours so that it was sufficient to repeat the treatment only three times daily. I then found no vibrios in the secretion. After continuing this treatment for some days the symptoms disappeared completely, but if I leave off they return till toward the end of June."

Helmholtz's experiments began in the summer of 1867 and in 1872 he told Binz that his fever was quite cured and that several others had, by his advice, tried the same treatment with success.

Although we now have reason to believe from the observations of Blakely, Bostock and Bosworth that true hay fever is the result of the irritation set up by the pollen of certain flowering plants in individuals having a neurotic idiosyncrasy against them and that the organisms seen by Helmholtz were probably fragments of spores containing the fovilla of the pollen cells the clinical observations were accurate, the description of the disease eminently truthful, and the methods of examination were in accord with the teachings of modern science.

In 1877 Werner von Siemens founded the Physico-Technical Institute at Berlin, and Helmholtz, his life-long friend, was chosen as its first Director. This position furnished him with some rest from teaching, but he still continued to deliver lectures twice a week in the University.

Five years after the demise of his son, Helmholtz sustained a further loss in the death of his favorite pupil, Heinrich Hertz, best known as the discoverer of electro-magnetic or "Hertzian" waves. We may understand something of his grief from the following words which Helmholtz wrote but a few months before his own death: "The news of the death of this favorite of genius was a severe shock to all who recognize the development of the individual, both as regards mental capacity and the victory of the soul over the passions and opposing powers of nature. Endowed with the rarest gifts of mind and character, he has in his short life reaped a harvest in a field in which many of the most talented of his scientific brethren had labored in vain. In classical times his death would have been regarded as a sacrifice to the envy of the gods. Nature and fate co-operated in his development. In him we found all the qualities required for the solution of the hardest problems in science. . . . Heinrich Hertz appeared to be predestined to disclose new vistas into the unpenetrated depths of nature; but all these hopes were crushed by the insidious disease which slowly and unceasingly crept on until it destroyed the life we esteemed so valuable. I myself deeply feel the loss, as I have always looked on Hertz as the one of all my students who had entered into the innermost circle of my scientific thoughts, and the one in whose ultimate development and success I dared to place my surest hopes."

In 1894, the year of his death, appeared a new edition of his *opus magnum*, the "Handbuch der Physiologischen Optik," a fitting crown to a long and successful life.

There is a matter to which the particular attention of this audience may well be drawn and that was the habit of Helmholtz to deliver popular lectures. Here was a man whose whole time was occupied in considering the most abstruse problems, whose every day teaching involved the use of terms intelligible only to minds with a special training, and yet he did not consider it outside his province to lay before the public the results of his own scientific experience and that of others. When Tyndall's lectures were published in German, Helmholtz wrote the preface and maintained that such popular presentations of scientific subjects were calculated to stimulate thought and to awaken an interest in scientific work. There can be no doubt but that his own public explanations of the phenomena of sight, of hearing, of the theories of music, of color and of the art of painting, may serve as models for popular lectures of all sorts. One may venture the assertion that medical topics discussed before public audiences in a tactful manner are not only useful in combating many ignorant ideas entertained by otherwise intelligent people, but they go a long way towards preserving these same persons from the machinations of the charlatans and panacea-vendors that infest the community. Do we not owe it to the public who, in a sense, are our medical wards, to provide them with authoritative teaching in physiology and pathology? If the elementary mysteries of biology and pathology are not publicly expounded by worthy representatives of the medical profession, it is no great wonder that the laity investigate them, to their hurt, elsewhere.

Reference has already been made to the mountaineering expeditions of Helmholtz. These strongly remind one of Tyndall. If one reads, first, the Helmholtz lecture on *"Eis und Gletscher"* and then Tyndall's "Glaciers of the Alps," or his "Forms of Water," he will surely feel that they were written by the same kind of man in an atmosphere that stimulated while it satisfied not only the inquiry into material, but into those immaterial things that both approached with a reserve tinctured by reverence.

Honors of all kinds flowed in on Helmholtz during the latter part of his life. He was ennobled by the Emperor William I, and the present monarch sent him an autograph letter on the celebration of his 70th birthday. This event was considered not only of national but of international importance. The Kings of Sweden and Italy, the Grand Duke of Baden and the President of the French Republic, conferred upon him the insignia of various orders. He was the recipient of many university degrees, while academies and learned societies the world over sent congratulatory addresses. A Helmholtz medal, to be awarded for distinguished services to science, was struck in his honor. At a banquet shortly afterwards, Helmholtz had the pleasure of presenting the first medal to his friend, Du Bois Reymond, after a speech so characteristic of the man that I cannot refrain from quoting a portion of it:

"It is the greatest honor men of science could pay to me to connect my name with this medal, which will stamp the progress of science in future times. Science. to modern humanity, proclaims peace. The scientific man does not work for his own welfare, but for that of his nation, and for the whole of humanity, especially for those who are sufficiently educated to enjoy the fruits of science. You desire to associate my name with this medal, and to hold me up to coming generations as an example of an investigator. I waver between a feeling of joy and a feeling of grave responsibility. I have a proud joy that the result of my thoughts is to work on to future generations far beyond my individual life. You will also understand that as a father cares for his offspring, and endeavors to help them, so I have also a love for the children of my thought. These contain the best of my convictions; I lay upon them the utmost stress; and I rejoice if the further development of science is to be in their direction. But the doubt may arise, whether my own ideals are not too narrow, and my principles sometimes too imperfect, for the wants of humanity in all time. If so, I hope the awarders of this medal in the future will not confine themselves to what I have accomplished, but I should like to wave on high the one banner on which are inscribed the words, that the purpose of science is to comprehend reality and the play of phenomena as regulated by law."

As you know, in 1893 he visited the Columbian Exposition, and afterwards made a tour over a part of the United States and Canada. On the return journey, just before landing at Hamburg, he had an attack of vertigo, and fell down the ship's companion-way. He received a severe scalp wound and suffered a concussion of the brain. This was followed in July, 1894, by a cerebral hemorrhage. He lingered two months longer, dying September 8, 1894, in his 73d year.

From personal acquaintance and from portraits we all know Helmholtz's appearance. He had a well-knit, erect frame, a quiet, graceful carriage, and a fine, well-developed face and head. Although his manner was reserved and dignified, he was always kind and courteous.

Of Helmholtz's attitude toward religion nothing definite can be said. Like Darwin, he considered religious questions so purely personal that he rarely mentioned them even to intimate friends. Perhaps, with Spinoza—another philosopher having affiliations with the ophthalmic art—he felt that the free man deliberates not upon matters of death or of after-death, but on the problems of everyday life. In any event, we have chiefly to deal with the achievements of a useful, noble and pure career, and in so far as we strive to imitate such a master do we surely keep his memory green.

APPENDIX—DESCRIPTIVE LIST OF THE OPHTHALMOSCOPES

IN THE HISTORICAL EXHIBIT, ST. PAUL MEETING OF THE AMERICAN MEDICAL ASSOCIATION. PREPARED BY DR. HARRY FRIEDENWALD, BALTIMORE.

Older Ophthalmoscopes.

HELMHOLTZ. 1851.

1. Original form, described in Helmholtz's monograph "Beschreibung eines Augenspiegels, etc., Berlin, 1851." Formerly in the possession of Albrecht von Graefe. See Plate I, No. 1. Loaned by Dr. Harry Friedenwald, Baltimore, Md.

2. Similar. Angle of glass plates 25°. Formerly belonged to Dr. Julian J. Chisholm. Loaned by Drs. Herbert Harlan and F. M. Chisolm, Baltimore, Md. See Plate I, Fig. 12.

3. Similar to 1. Angle of glass plates 30°. Presented in 1853 by Dr. Eduard Jaeger, of Vienna, to Dr. John Brinton, and in 1870 by the latter to Dr. Wm. Thomson, of Philadelphia. See Plate I, Fig. 49. Loaned by Dr. Thomson, through Messrs. Bonschur & Holmes, Philadelphia.

4. Modification. The lenses are inserted in a slit at the side. See Plate I, Fig. 41. Sent to Dr. John H. Dix, of Boston, by Prof. Sichel, of Paris. Loaned through kindness of Dr. B. Joy Jeffries, Boston.

5. Similar to 4. Made in Halle, Germany. Loaned by Dr. H. B. Young, Burlington, Ohio.

RUETE. 1852.

First *concave* mirror. First practical instrument for indirect method. Described in "Der Augenspiegel und das Optometer. Göttingen, 1852." See Plate II. Loaned by Dr. Haskett Derby, Boston.

COCCIUS.

"See Anwendung des Augenspiegels. Leipzig, 1853."

1. Plane mirror with condensing lens attached. Plate with circular perforation to reduce size of mirror. See plate III, Fig. 71. Loaned by Dr. Lucian Howe, Buffalo.

2. Modification: Circular mirror. Plane, metallic mirror, with convex lens attached, distance between mirror and lens adjustable. See Plate III, Fig. 26. Makers: Messrs. Tiemann & Co., New York. Loaned by them.

3. This instrument has a fixed distance between the ophthalmoscope and the lens; in the original instrument this distance is variable. See Plate III, Fig. 25. Loaned by Messrs. Tiemann & Co., New York.

4. With slide containing six lenses behind mirror. Loaned by Wills Eye Hospital, through Dr. Conrad Berens, of Philadelphia.

ZEHENDER. 1854.

1. *Original form* (described in Graefe's Archiv, I, 1, 121). Convex, metallic mirror. See Plate III, Fig. 47. Loaned by Dr. F. Koeller, of Pittsburg.

2. Slightly modified. Makers: Messrs. Otto and Reinders, New York. See Plate III, Fig. 29. Loaned by Dr. Haskett Derby, of Boston.

BURROW. 1856.

1. (See Graefe's Archiv III, 2, 68.) Heterocentric Reflector: Made of biconvex lens silvered on back, in pillbox case. Loaned by Dr. B. Joy Jeffries, of Boston.

2. Similar to I, but with handle attached. See Plate III, Fig. 30. Loaned by Dr. Haskett Derby, of Boston.

3. Modification by Elsberg, revolving sector with four lenses back of mirror. See Plate III. Fig. 20. Loaned by Messrs. Tiemann & Co., New York.

JAEGER. 1854.

1. Large Jaeger (described in "Staar and Staar Operationen, Wien, 1854). Three reflectors: (*a*) plates of glass; (*b*) concave silvered mirror; (*c*) plane silvered mirror. See Plate III, Fig. 40. Used by Dr. Jeffries in Vienna in 1858 and 1859. Loaned by Dr. B. Joy Jeffries, of Boston.
2. Loaned by Dr. Haskett Derby, of Boston.
3. Loaned by Dr. Risley, of Philadelphia, through Messrs. Bonschur and Holmes, of Philadelphia.
4. The plates of glass are protected on the back by a metal shield with central opening. Loaned by Wills Eye Hospital, through Dr. Conrad Berens, Philadelphia.
5. Loaned by Dr. Barck, of St. Louis.
6. Mauthner's pattern.. See Mauthner "Ophthalmoscopie," 1868, page 108; more compact than original. Formerly belonged to Dr. Noyes, of New York. Loaned by Dr. D. W. Hunter, of New York.
7. Similar to 6. Loaned by Dr. Wm. Thomson, of Philadelphia, through Messrs. Bonschur and Holmes, of Philadelphia.
8. Similar to 1. Loaned by Dr. C. H. Williams, of Boston.
9. Similar to 4. Loaned by Dr. C. H. Williams, of Boston.
10. Incomplete. Loaned by Dr. Callan, of New York, through Mr. E. B. Meyrowitz.
11. *Dr. G. Strawbridge's Modification.* Three revolving Rekoss discs. See Plate III, Fig. 52. See Trans. Amer. Ophth. Soc., 1871, page 120. Loaned by Dr. Strawbridge, of Philadelphia, through Messrs. Bonschur and Holmes.

Stationary Ophthalmoscopes.

LIEBREICH.

1. See Plate IV (described in Arch. f. Ophth., 1854, Vol. I, 2). Loaned by Dr. Hermon Thomas, of Philadelphia, through Messrs. Bonschur and Holmes, of Philadelphia.
2. Similar to 1. Loaned by Drs. Chisolm and Harlan, of Baltimore.
3. *Fixed Model of Follin:* Made by Nachet, of Paris. See Plate IV. Loaned by Dr. Haskett Derby, of Boston.
4. *Galezowski:* 1862. See Acad. de Med. France, 7 Jan., 1862. This is a modification of Liebreich's Stationary Ophthalmoscope and of Hasner's. See Plate IV. Makers: Messrs. Otto and Reynders, of New York; formerly in possession of Dr. E. N. Brush. Presented to and loaned by Dr. Harry Friedenwald, of Baltimore, Md.
5. *Galezowski:* Concave metallic mirror and collecting lens contained in telescopic tube; opening on side for entrance of light; one end fits on patient's face; may be used in light room. Maker: Charriere, of Paris. Loaned by Drs. Herbert Harlan and Frank M. Chisolm, of Baltimore, Md.
6. *Galezowski:* Similar to 4 and 5, metal mirror. Loaned by Wills Eye Hospital, through Dr. Conrad Berens.
7. *Galezowski:* Similar to 4 and 5. Loaned by Dr. Charles H. May, of New York.

Demonstration Ophthalmoscopes.

1. *Schweigger:* Demonstration Ophthalmoscope for two observers. Described in Berl. Klin. Wochenschr., 1871, p. 581. See Plate IV. (Similar to Sichel's instrument, as described in Graefe & Saemisch's Handbook, First Ed., Vol III, p. 161.) Makers: Messrs. Paetz & Flohr, of Berlin: formerly in possession of Dr. Noyes. Loaned by Dr. D. W. Hunter, of New York.
2. *Graefe-Peppmüller:* Demonstration Ophthalmoscope. See Plate IV, Fig. 66. Described at the 50th Versammlung Deutscher Aerzte und Naturforscher, 1877. Loaned by Dr. Charles H. May, of New York.
3. *Graefe-Peppmüller:* Small mirror attached to Liebreich's Ophthalmoscope, similar to 2. Loaned by Dr. Harry Friedenwald, of Baltimore, Md.
4. *Schoeler:* Demonstration Ophthalmoscope: Small mirror set

at angle just behind opening of Ophthalmoscope: described in Schoeler's Jahresbericht der Klinik fuer 1876, p. 51. Loaned by Dr. C. H. Williams, of Boston.

Simple Ophthalmoscopes.

1. *Small Jaeger:* See Mauthner's "Ophthalmoscopie," p. 108. similar to early "Liebreich." Concave metal mirror. The fork holding the correcting lens is detachable. Makers: Messrs. Tiemann & Co., of New York. Loaned by them.

2. *Liebreich:* Earliest pattern. Metal mirror. Makers: Messrs. Paetz & Flohr, of Berlin. Loaned by Dr. W. B. Hunter, of New York (formerly in possession of the late Dr. Noyes).

3. *Liebreich:* Earliest form, concave metal mirror. Loaned by Dr. B. Joy Jeffries, Boston.

4. *Liebreich:* Later model, concave metal mirror. Loaned by Dr. F. M. Chisolm, Baltimore, Md.

5. *Liebreich:* More modern form, glass mirror, long handle. Loaned by Messrs. Tiemann & Co., New York.

6. *Liebreich:* Later model. Loaned by Dr. B. Joy Jeffries, Boston.

7. *Liebreich:* Small model. Loaned by Messrs. Tiemann & Co., New York.

8. *Liebreich:* Very small form. Loaned by Dr. C. H. Williams, Boston.

9. *Anagnostakis:* Similar to Liebreich, but of very short focus. Described in "Essai sur l'exploration de la Retine," Paris, 1854. Made by Soleil, Paris. Loaned by Dr. C. H. Williams, Boston.

10. *Anagnostakis:* Similar to 9. Loaned by Wills Eye Hospital, through Dr. Conrad Berens, of Philadelphia.

11. *Nachet:* Modification of Liebreich: Small revolving disc with four correcting lenses attached to back of mirror. Loaned by Dr. Flemming Carrow, Ann Arbor, Mich.

12. *Desmarres:* Concave metal mirror single sight hole. Maker: Charriere, Paris. Loaned by Dr. Haskett Derby, Boston.

13. *Desmarres:* Concave metal mirror with two sight holes. See Plate III, Fig. 39. Maker: Charriere, Paris. Loaned by Dr. B. Joy Jeffries, Boston.

14. *Desmarres:* Two openings; metal mirror; similar to 13. Loaned by Dr. C. F. Clark.

15. *Pocket Ophthalmoscope:* Concave mirror, with metal protecting cover; the cover is attached to the mirror by a hinge, and when open is used as handle. Makers: Messrs. Curry & Paxton, London. Loaned by Dr. Harry Friedenwald, Baltimore, Md.

16. *Argyll-Robertson Ophthalmoscope:* Made by Gardiner in Edinburgh. 1878. The whole is about the size of a large flat pillbox, of which the mirror forms the lid: the box contains a convex lens; very compact. Loaned by Dr. A. W. Stirling, Atlanta.

17. *Pocket Ophthalmoscope:* According to Donders: Very compact, similar to 16. Loaned by Dr. Dudley Reynolds, of Louisville, Ky.

Binocular Ophthalmoscopes.

1. *Giraud-Teulon Binocular Ophthalmoscope:* Made by Nachet, Paris. See Annal. d'oculist, 1861. Cong. méd. de France, 1863. Annal d'oculist, 1867. See Plate III, Fig. 53. Loaned by Dr. G. Strawbridge, through Messrs. Bonschur & Holmes, of Philadelphia.

2. *Giraud-Teulon:* Made by Nachet, formerly in possession of Dr. Metz, of Massillon. Loaned by Dr. E. P. Morrow, Canton, Ohio.

3. *Early Giraud-Teulon:* See Plate III, Fig. 97. Loaned by Dr. C. H. Williams, Boston.

4. *Lawrence's Binocular Ophthalmoscope:* Modification of Giraud-Teulon. Makers: Murray & Heath, London. See Plate III, Fig. 45. Loaned by Dr. B. Joy Jeffries, Boston.

5. *Giraud-Teulon:* Old form. Loaned by Dr. Callan, of New York, through Mr. E. B. Meyrowitz.

6. *Giraud-Teulon Binocular Ophthalmoscope:* With spectacle attachment. Loaned by Dr. Casey A. Wood.

7. *Lawrence's Binocular Ophthalmoscope:* (Modification of Giraud Teulon) made by Grunow. Formerly property of Dr. Noyes. Loaned by Dr. D. W. Hunter, New York.

8. *Lawrence's Binocular Ophthalmoscope:* With Loring Tilting Mirror. See Plate III, Fig. 57. Made by Bonschur & Holmes, Philadelphia. Loaned by Dr. H. I. Jessop, through Messrs. Bonschur & Holmes, Philadelphia.

Electric Ophthalmoscopes.

1. *Schweigger's Electric Light Ophthalmoscope:* See Helmholtz Festschrift, 1889. Maker: Sydow, Berlin. Loaned by Dr. Harry Friedenwald, Baltimore, Md.
2. *Dennett's:* Shown in drawing. See Transact. Amer. Ophth. Soc., 1885 and 1886.
3. *Meyrowitz's:* Attachable to any Loring Ophthalmoscope. Loaned by Mr. E. B. Meyrowitz.
4. *Wolff's Ophthalmoscope:* Received too late for exhibit. See Zeitschrift fuer Augenheilkunde, February, 1901.

Refracting Ophthalmoscopes.

Loring.

1. Mirror not tilting, early model. See Plate V, Fig. 44. Loaned by Dr. B. Joy Jeffries, Boston.
2. Early model, one Rekoss disc. See Plate V, Fig. 17. Made by Messrs. Tiemann & Co., New York. Loaned by them.
3. Early model. One Rekoss disc exposed. Mirror not tilting. See Plate V, Fig. 18. Made and loaned by Messrs. Tiemann & Co., New York.
4. Early model. See Plate V, Fig. 16. Made and loaned by Messrs. Tiemann & Co., New York.
5. Three interchangeable discs. Described in Trans. Am. Ophth. Soc., 1869, p. 47. See Plate V, Fig. 73. Made by Hunter. Loaned by Mr. Alex. Shaw, New York.
6. Three discs similar to 5. Loaned by Dr. C. H. Williams, Boston.
7. Slight modification of 5. Three discs. European make. See Plate V, Fig. 80. Loaned by Dr. Harry Friedenwald, Baltimore.
8. Similar to 7. European make. See Plate V, Fig. 77. Loaned by Dr. Dudley Reynolds, Louisville, Ky.
9. Three interchangeable Rekoss discs with *Wadsworth Tilting Mirror.* See Boston Med. and Surg. Journ., 1877, p. 105. Maker: H. W. Hunter, New York. Loaned by Dr. Wadsworth, Boston.
10. Single disc (12 concave lenses, 12 convex lenses). Tilting mirror. See Plate V, Fig. 19. Loaned by Messrs. Tiemann & Co., New York.
11. Early model. Disc contains two concentric rows of lenses and can be pushed up and down on handle; mirror fixed and not tilting. Made by Hunter, New York. See Plate V, Fig. 62. Formerly in possession of Dr. Noyes. Loaned by Dr. D. W. Hunter, New York.
12. *First Form of Loring Tilting Mirror:* See Plate V, Fig. 64. The little metal plate seen above is placed on the mirror to reduce the size of the latter. One Rekoss disc with two rows of lenses, as in 9, moved by cog-wheel. Made by H. W. Hunter, New York. Formerly property of Dr. Noyes. Loaned by Dr. D. W. Hunter.
13. *Earliest Form of Sector:* See Plate V, Fig. 72. Loaned by Mr. Alex. Shaw, New York.
14. *Latest pattern,* as made by Messrs. Bonschur & Holmes, Philadelphia. See Plate V. Loaned by Messrs. Bonschur & Holmes.
15. *Latest form,* as made by Mr. E. B. Meyrowitz. Loaned by Mr. Meyrowitz. See Plate V.
16. *Latest model,* as made by Messrs. Chambers, Inskeep & Co. See Plate V.

Roth.

1. Refracting Ophthalmoscope: Modification of Loring's latest. The revolving sector is replaced by a plate containing three lenses which moves automatically. Described in Klin. Monatsbl. f. Augenh., 1894. See Plate V. Loaned by Mr. E. B. Meyrowitz.
2. Improved model. Loaned by Mr. E. B. Meyrowitz.
3. Loaned by Messrs. Chambers, Inskeep & Co.

Knauer.

1. Refracting Ophthalmoscope: Two discs forming all combinations automatically. Loaned by Dr. Harry Friedenwald, Baltimore, Md.

2. Loaned by Mr. E. B. Meyrowitz, New York.

Knapp.

1. *Knapp:* Two discs, the upper has one aperture and 13 concave lenses; the lower, one aperture and 13 convex lenses. The discs overlap. See Archives of Ophth. and Otol., Vol. III, No. 2, 1874. Loaned by Surg. Gen. Museum, Washington.

2. *Small Knapp Ophthalmoscope:* Single disc for lenses. Makers: Messrs. Tiemann & Co., New York. Loaned by them.

3. *Small Knapp Ophthalmoscope:* Single disc. one opening and 23 lenses, flat mirror. See Arch. of Ophth. and Otol., Vol. IV, No. 1, 1874. Loaned by Dr. H. Knapp, New York.

4. *Knapp:* Large disc ophthalmoscope, with crystal lenses. Disc 2 inches in diameter, containing 16 convex and 16 concave lenses, and one opening. Loaned by Dr. H. Knapp, New York.

Keyser.

1. Very small refracting ophthalmoscope. See Phila. Med. Times, 1887-8, Vol. XVIII, p. 167. Loaned by Dr. Wm. Thomson, through Messrs. Bonschur & Holmes, Philadelphia.

Harlan.

1. Combination of Loring, Knapp & Noyes. Two discs superimposed, one rotated by serrated edge, the other by cogwheel. Loaned by Messrs. Bonschur & Holmes, Philadelphia.

Hirschberg's.

1. See Deutsch. Zeitsch. f. Prak. Med., 1877, p. 353. Two Rekoss discs. Three mirrors, one large plane mirror, one large concave mirror, one small plane mirror set at angle. Loaned by Dr. Harry Friedenwald, Baltimore, Md.

Dudley.

1. Two discs, one containing + lenses, the other — lenses; slightly decentered axes, so that one is moved on one side, the other on the other side of the mirror. Loaned by Dr. Dean.

DeWecker.

1. DeWecker's Ophthalmoscope. One disc with 11 + Spher., and 13 — Spher. lenses. Similar to Loring's one disc Ophthalmoscope. Loaned by Dr. Casey A. Wood.

2. One disc with 20 lenses from + 0.5 to + 10 D. Converted by slide containing — 10.5 D. into — 0.5 to — 10 D. Loaned by Dr. C. H. Williams. Boston.

Landolt.

1. Early pattern. Loaned by Dr. Zimmerman, through Messrs. Bonschur & Holmes, Philadelphia.

2. Late model. See Bull. Soc. de Chir. d. Paris, 1876, Vol. II, p. 359. Loaned by Dr. Wm. Thomson, Philadelphia, through Messrs. Bonschur & Holmes, Philadelphia.

3. With Wadsworth Mirror. Loaned by Dr. Bane.

4. With Tilting Mirror. Loaned by Dr. Fox, through Messrs. Bonschur & Holmes.

Fox.

1. Early model. Loaned by Dr. Webster Fox, through Messrs. Bonschur & Holmes, Philadelphia.

2. One disc and additional sector. Wadsworth Mirror. Loaned by Dr. Fox, received through Messrs. Bonschur & Holmes.

Jackson.

1. Two vertical slides with + and — spheres. Earliest form. Loaned by Dr. Jackson, Denver, Colo.

2. Improved form, circular tilting mirror. Loaned by Dr. Jackson, Denver, Colo.

3. Latest improved form, Loring tilting mirror. Loaned by Messrs. Bonschur & Holmes, Philadelphia.

MORTON.

1. Modification of Cooper's Ophthalmoscope. Contains chain of lenses instead of Rekoss disc. Also large plane and concave mirrors and small concave mirror set at angle. Made by Curry & Paxton, London. Loaned by Messrs. Tiemann & Co., New York.
2. Modified: Two inclined mirrors, plane and concave. Loaned by Dr. Harry Friedenwald, Baltimore, Md.
3. American form, as made by Messrs. Bonschur & Holmes, Philadelphia. Loaned by them.

Refracting Ophthalmoscope.

1. Two small mirrors (concave and plane) reversible. Two revolving discs moved by cogs, one containing 10 convex, the other 10 concave lenses. Author not identified. French model. Loaned by Dr. F. M. Chisolm, Baltimore, Md.

Jessop's Pocket Refraction Ophthalmoscope.

1. See Brit. Med. Journ., 1887, pt. 2, p. 724. Loaned by Dr. Harry Friedenwald, Baltimore, Md.
Howe's Pocket Refracting Ophthalmoscope: See Am. Journ. of Ophth., February, 1893.
1. Very compact. Loaned by Dr. Lucian Howe, Buffalo.

Refracting Ophthalmoscopes with Cylindrical Lenses.

1. *Burnett's* Modification of Loring's Ophthalmoscope. Two mirrors; attachment for cylindrical glasses. See Amer. Ophth. Society, 1885, p. 589. Loaned by Dr. Shallerson, through Messrs. Bonschur & Holmes, Philadelphia.
2. Callan's Ophthalmoscope, with Stokes constant axis cylinder. Loaned by Dr. Callan, through Mr. E. B. Meyrowitz.
3. *Parent:* Ophthalmoscope. Early form, with Wadsworth mirror. Loaned by Dr. Casey A. Wood, Chicago.
4. *Parent:* (Old pattern.) Loaned by Mr. E. B. Meyrowitz.
5. *Parent:* Contains spherical and cylindrical correcting lenses. See Rec. d'Ophthal., 1883, p. 628. Loaned by Dr. C. M. Culver, Albany, N. Y.
6. *Parent:* Made by Chambers, Inskeep & Co. Attachment with *cylindrical lenses.* Loaned by Dr. Casey A. Wood, Chicago.

Boeckman's Combination Trial Case and Ophthalmoscope.

1. The instrument consists of a handle and three forks into which the circular mirrors and the correcting glasses of small trial case can be placed. Very simple. Loaned by Dr. Boeckman, of St. Paul, Minn.

Skiascopic Mirrors.

1. Small, plane mirror according to Jackson. Makers: Messrs. Bonschur & Holmes, Philadelphia. Loaned by Dr. Harry Friedenwald, Baltimore, Md.
2. Large plane mirror, with pupillometer on back. Maker: Sydow, Berlin. Loaned by Dr. Harry Friedenwald, Baltimore, Md.
3 to 15. Thirteen varied forms of skiascopic mirrors. Made by Messrs. Chambers, Inskeep & Co., Chicago.
16. *Roth's Skiaskop:* With tape and correcting lenses. Made by Sydow, Berlin. Loaned by Dr. Harry Friedenwald, Baltimore, Md.
17 to 23. Seven forms of Brown Pusey's combination Ophthalmoscope and Skiascope. Made by Messrs. Chambers, Inskeep & Co., Chicago. Loaned by Dr. Brown Pusey, Chicago.